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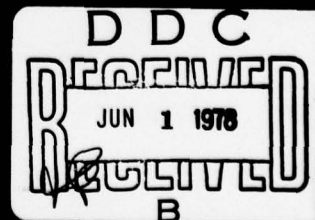
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MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
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⑥ ADVANCED ELECTRONIC TECHNOLOGY

⑨ QUARTERLY TECHNICAL SUMMARY REPORT. 1 Nov 77 -  
TO THE 31 Jan 78.  
AIR FORCE SYSTEMS COMMAND

⑩ Melvin A. Herlin  
Alan W. McWhorter

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# INTRODUCTION

This Quarterly Technical Summary covers the period 1 November 1977 through 31 January 1978. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

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DATA SYSTEMS  
DIVISION 2

INTRODUCTION

This section of the report reviews progress during the period 1 November 1977 through 31 January 1978 on Data Systems. Separate reports describing other work of Division 2 are issued for the following programs:

Seismic Discrimination	ARPA/NMRO
Distributed Sensor Networks	ARPA/IPTO
Education Technology	Bureau of Mines, ARPA/CTO
Network Speech Processing	OSD-DCA
Digital Voice Processing	AF/ESD
JTIDS Speech Processing	AF/ESD
Packet Speech	ARPA/IPTO
Wideband Integrated Voice/Data Technology	ARPA/IPTO
Radar Signal Processing Technology	ARMY/BMDATC
Nuclear Safety Designs	NRC

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## DIGITAL COMPUTERS GROUP 23

### I. INTRODUCTION

Fabrication of the first amorphous-Si isolated 64K MNOS memory chips is complete, and air-isolated samples should be available within a few weeks.

### II. APPLICATIONS

#### A. Serial/Parallel Converter

Detailed mask design for the new converter is nearly completed. This mask set will incorporate the changes described in the last Quarterly Technical Summary: reduced flip-flop switched current and smaller transistors, addition of emitter followers to the flip-flops, and modifications to the clock driver.

#### B. MNOS Capacitor Memory

A new run of  $30 \times 30$  MNOS capacitor arrays was fabricated with amorphous-Si isolation using an improved Ne implant mask. Tests on these arrays verified the earlier results of improved digit-to-digit isolation and yield over the air-isolated devices. This experiment demonstrated that the Ne implant process does not degrade the storage and readout properties of the MNOS capacitors.

The first 64K (65,536)-bit memory chips with amorphous-Si isolation have been fabricated, and air-isolated samples should be available within a few weeks.

Design improvements for a second version of the 64K chips are being considered. The use of transistor pulldowns in place of resistors on the digit lines and lower value, p-type, resistors for word-line pulldown will increase memory speed and solve several problems with no added processing steps.

#### C. MUDPAC (16- $\times$ 16-Bit Serial Multiplier)

The test chip masks are being laid out. This chip will give knowledge of oscillator control and oscillator and adder speed. Modifications in the design to allow faster resolution of carries or two-bit-per-clock operation are being investigated. If the extra logic can be made to fit on the chip, the multiply time could be reduced by about 35 percent.

### III. IC PROCESSING

#### A. MNOS Array Selection Transistors

Test results of the first 64K air-isolated MNOS run after first metal etch indicated low breakdown due to thin gate oxide. The gate-oxide thickness has been increased from 1000 to 1500 Å on the second run to take into account the effects of subsequent HF and plasma etching processes and to insure coverage of the 450-Å silicon step at the epi-source and epi-drain interfaces. Since both amorphous and air-isolated runs in process exhibit punchthrough at 15 V (drain to substrate) the n-tub implantation and drive-in cycle will be revised by implanting additional phosphorous and possibly extending the drive-in time. Computer simulations and experimental results show that a dose of  $5 \times 10^{12}$  ions/cm<sup>2</sup> combined with a drive-in at 1250°C for 4 hr will provide punchthrough voltages in excess of 40 V.

### B. Poly-Ox Isolation

A new selective oxidation technique devised to eliminate the oxide bump at the nitride mask boundary produces a trench along the boundary where the bump was formerly located. The trench exposed some of the silicon island sidewall resulting in several shorted junctions. A short oxidation, utilizing the parabolic growth rate of silicon dioxide on silicon, grows oxide in the trench only, thereby passivating the exposed silicon and reducing the depth of the trench.

The poly-ox process has been simplified by elimination of the oxidation cycle following the collector sinker predeposition. This oxide was originally intended to protect the n-type sinker areas from subsequent p-type predepositions. However the n-type doping concentration is so high that the moderate p-type predeposition does not appreciably affect the sinker resistivity. The phosphorous sinker predeposition is now being accomplished by ion implantation in lieu of the phosphorous-doped glass.

### C. Self-Aligned Transistors

Transistors fabricated using the simultaneous emitter and base-drive-in procedure exhibit peak  $f_T$ 's of 7 to 8 GHz reproducibly. The basewidth is difficult to measure, but is estimated to be on the order of 1000 Å. However, the contribution to  $r_b'$  by the active base is larger than before, and limits circuit performance. It is expected that some combination of deep-implant and limited drive-in should be optimal for our design.

Transistors fabricated with a thinner and lower resistivity epitaxial layer have shown increased current capability before  $f_T$ -vs-collector current falloff. This implies that, for a given operating current, smaller device geometries may be used, reducing parasitic capacitance.

### D. Photolithography and Plasma Etching

The first run of air-isolated and amorphous MNOS memory wafers was processed through photolithography with no unusual problems, and remarkably little undercut on the first air-isolated lines. After etch rates had been established, selective plasma etching of contact cuts through nitride on oxide and/or silicon was carried out successfully.

### E. Ion Implanter

The ion implanter is being modified with a new magnet to enable implant of heavier ions and a new filter to improve cleanliness of doubly charged ion beams.

## IV. ANALYSIS

### A. A Defect Model for Memory Nitride

Certain point defects in a-Si<sub>3</sub>N<sub>4</sub> appear to be able to explain not only the charge storage properties of memory nitride but also the fatiguing (endurance) and charge loss (retentivity) that occur in MNOS memory devices. The defects themselves are thought to be twofold-coordinated nitrogen atoms. The normal threefold coordination cannot be satisfied at these points in the a-Si<sub>3</sub>N<sub>4</sub> structure because of constraints imposed by neighboring atoms. If these defect centers are assumed to behave as electronic gap states of the Mott, Davis, and Street type (MDS states), then much of the experimentally observed behavior of a-Si<sub>3</sub>N<sub>4</sub> can be explained in terms of this single type of defect.



COMPUTER SYSTEMS  
GROUP 28

As previously reported, Lincoln-developed software monitors continuously record performance data on the VM/370 interactive operating system. Such information is invaluable both to verify expected performance and to provide a basis for future planning. During the quarter, some recent data was plotted and compared with corresponding data from the previous year. Although the results were neither dramatic nor surprising, they did provide an objective measure of recent user impressions of slow response.

Since total CPU use has been at or very near saturation for a long time, the plot of this statistic is essentially flat. The changes have occurred in the distribution of this major resource. Over the year, and particularly in the past quarter, the total number of users logged on has risen from an average of about 60 to an average of just under 80. These values and all others discussed here are for the entire regular working day and do not reflect peak loads which typically occur at midmorning and midafternoon. Other supporting statistics show that most of this increase in use has been in relatively short interactions of a few seconds or less. This also serves as a statement that the system is properly tuned to favor such small users at the expense of large jobs, as intended by local operating policy. An interesting side note of this comparative study is the fact that it was easy to verify the value of hardware changes that had been made during the year to reduce supervisor overhead.

Looking to the future, there are no major system imbalances to be adjusted. There are some quantity problems, perhaps, in the area of secondary and swapping storage. However, the subjective impression of slow response is a true reflection of heavy loading and not particular inefficiencies nor readily malleable constrictions. This in turn indicates continued attention to relatively small incremental upgrades, but long-range considerations of a considerably broader nature.

SOLID STATE  
DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period 1 November 1977 through 31 January 1978. The Solid State Research Report for the same period describes the work of Division 8 in more detail. Funding is primarily provided by the Air Force, with additional support provided by the Army, ARPA, NSF, and DOE.

A. L. McWhorter  
Head, Division 8  
I. Melngailis  
Associate Head

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DIVISION 8 REPORTS  
ON ADVANCED ELECTRONIC TECHNOLOGY

15 November 1977 through 15 February 1978

PUBLISHED REPORTS

Journal Articles

JA No.

- |      |                                                                                                                                                                    |                                                |                                                                                                                                                        |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4034 | Far-Infrared Photoconductivity in High Purity GaAs                                                                                                                 | G. E. Stillman<br>C. M. Wolfe<br>J. O. Dimmock | Chapter 4 in <u>Semiconductors and Semimetals, Vol. 12, Infrared Detectors</u> (Academic Press, New York, 1977), pp. 169-288                           |
| 4353 | Brillouin Scattering in Semiconductors                                                                                                                             | A. S. Pine                                     | Chapter 6 in <u>Topics in Applied Physics, Volume 8: Light Scattering in Solids</u> , M. Cardona, Ed. (Springer-Verlag, Heidelberg, 1975), pp. 253-273 |
| 4486 | Surface Wave Device Fabrication                                                                                                                                    | H. I. Smith                                    | Chapter 4 in <u>Surface Wave Filters</u> , edited by H. Matthews (Wiley, New York, 1977), pp. 165-217                                                  |
| 4505 | Reflection Grating Filters                                                                                                                                         | R. C. Williamson                               | Chapter 9 in <u>Surface Wave Filters</u> , edited by H. Matthews (Wiley, New York, 1977), pp. 381-442                                                  |
| 4653 | Tunable Infrared Laser Sources for Optoacoustic Spectroscopy                                                                                                       | P. L. Kelley                                   | In <u>Optoacoustic Spectroscopy and Detection</u> (Academic Press, New York, 1977), pp. 113-131                                                        |
| 4739 | Measured Compositions and Laser Emission Wavelengths of $\text{Ga}_x\text{In}_{1-x}\text{As}_y\text{P}_{1-y}$ LPE Layers Lattice-Matched to InP Substrates         | J. J. Hsieh                                    | J. Electron. Mater. <u>7</u> , 31 (1978)                                                                                                               |
| 4741 | Phase Studies, Crystal Growth, and Optical Properties of $\text{CdGe}(\text{As}_{1-x}\text{P}_x)_2$ and $\text{AgGa}(\text{Se}_{1-x}\text{S}_x)_2$ Solid Solutions | J. C. Mikkelsen, Jr.<br>H. Kildal              | J. Appl. Phys. <u>49</u> , 426 (1978)                                                                                                                  |
| 4754 | Polarized Vibrational Raman Scattering Lineshape Parameters in Liquid CO and Liquid CO Mixtures                                                                    | S. R. J. Brueck                                | Chem. Phys. Lett. <u>53</u> , 273 (1978)                                                                                                               |

JA No.

- |      |                                                                                                                                         |                                                                                               |                                            |
|------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|--------------------------------------------|
| 4756 | Thermal Expansion and Seeded Bridgman Growth of $\text{AgGaSe}_2$                                                                       | G. W. Iseler                                                                                  | J. Cryst. Growth <b>41</b> , 146 (1977)    |
| 4775 | Chemisorbed Phases of $\text{H}_2\text{O}$ on $\text{TiO}_2$ and $\text{SrTiO}_3$                                                       | V. E. Henrich<br>G. Dresselhaus<br>H. J. Zeiger                                               | Solid State Commun. <b>24</b> , 623 (1977) |
| 4777 | Surface Relief Structures with Linewidths Below 2000 Å                                                                                  | D. C. Flanders<br>H. I. Smith<br>H. W. Lehmann*<br>R. Widmer*<br>D. C. Shaver*                | Appl. Phys. Lett. <b>32</b> , 112 (1978)   |
| 4780 | Effect of $\text{O}_2$ Pressure During Deposition on Properties of rf-Sputtered Sn-Doped $\text{In}_2\text{O}_3$ Films                  | J. C. C. Fan<br>F. J. Bachner<br>G. H. Foley                                                  | Appl. Phys. Lett. <b>31</b> , 773 (1977)   |
| 4785 | Infrared Four-Wave Sum and Difference Frequency Generation in Liquid $\text{CO-O}_2$ Mixtures                                           | H. Kildal<br>S. R. J. Brueck                                                                  | Appl. Phys. Lett. <b>32</b> , 173 (1978)   |
| 4792 | Crystal Structure and Ionic Conductivity of $\text{Li}_{14}\text{Zn}(\text{GeO}_4)_4$ and Other New $\text{Li}^+$ Superionic Conductors | H. Y-P. Hong                                                                                  | Mater. Res. Bull. <b>13</b> , 117 (1978)   |
| 4798 | Surface Acoustic Wave Properties of Fresnoite, $\text{Ba}_2\text{Si}_2\text{TiO}_8$                                                     | J. Melngailis<br>J. F. Vetelino*<br>A. Jhunjhunwala*<br>T. B. Reed<br>R. E. Fahey<br>E. Stern | Appl. Phys. Lett. <b>32</b> , 203 (1978)   |

Meeting SpeechesMS No.

- |       |                               |              |                                                                                                                                                                                                                           |
|-------|-------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4067C | Tunable Semiconductor Lasers  | A. Mooradian | In <u>Nonlinear Optics</u> (Academic Press, New York, 1977), p. 213                                                                                                                                                       |
| 4177  | Wavelength-Selective Surfaces | J. C. C. Fan | Chapter 8 in <u>Advances in Chemistry Series, No. 163: Solid State Chemistry of Energy Conversion and Storage</u> , J. B. Goodenough and M. S. Whittingham, Eds. (American Chemical Society, New York, 1977), pp. 149-164 |

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\* Author not at Lincoln Laboratory.



MS No.

4178	New Solid Electrolytes	H. Y-P. Hong	Chapter 10 in <u>Advances in Chemistry Series, No. 163: Solid State Chemistry of Energy Conversion and Storage</u> , J. B. Goodenough and M. S. Whittingham, Eds. (American Chemical Society, New York, 1977), pp. 179-194
4271	X-Ray Lithography	H. I. Smith D. C. Flanders	Jap. J. Appl. Phys. <u>16</u> , Suppl. 16-1, 61 (1977)
4383	Studies of Defect Surface States on SrTiO <sub>3</sub> Photoelectrolytic Electrodes	J. G. Mavroides V. E. Henrich H. J. Zeiger G. Dresselhaus J. A. Kafalas D. F. Kolesar	In <u>Proceedings, Symposium on Electrode Materials and Storage</u> , Philadelphia, 8-13 May 1977, Vol. 77-6 (The Electrochemical Society, Inc., Princeton, New Jersey, 1977), pp. 45-53
4433	Growth of Ni-Doped MgF <sub>2</sub> Crystals in Self-Sealing Graphite Crucibles	T. B. Reed R. E. Fahey P. F. Moulton	J. Cryst. Growth <u>42</u> , 569 (1977)
4480A	A New Signal Processing Device, the Integrating Correlator	R. W. Ralston D. H. Hurlburt F. J. Leonberger J. H. Cafarella E. Stern	<u>1977 Ultrasonics Symposium Proceedings</u> (IEEE, New York, 1977), pp. 623-628
4501	X-ray Replication of Sub-micrometer Linewidth Patterns	H. I. Smith D. C. Flanders	Proc. 35th Annual Mtg. EMSA, Boston, 22-26 August 1977, pp. 136-137
4545	Filter with Bandwidth Continuously Variable from 5 to 100 MHz	J. Melngailis R. C. Williamson R. H. Domnitz*	<u>1977 Ultrasonics Symposium Proceedings</u> (IEEE, New York, 1977), pp. 965-968
4547	Acoustoelectrically Scanned Gap-Coupled Si-Diode Array/LiNbO <sub>3</sub> Imaging Devices	F. J. Leonberger J. H. Cafarella R. W. Ralston E. Stern A. L. McWhorter	<u>1977 Ultrasonics Symposium Proceedings</u> (IEEE, New York, 1977), pp. 456-459
4549	Improved Acoustoelectric Schottky-Diode/LiNbO <sub>3</sub> Memory Correlator	R. W. Ralston J. H. Cafarella S. A. Reible E. Stern	<u>1977 Ultrasonics Symposium Proceedings</u> (IEEE, New York, 1977), pp. 472-477
4560	Case Studies of Successful Surface-Acoustic-Wave Devices	R. C. Williamson	<u>1977 Ultrasonics Symposium Proceedings</u> (IEEE, New York, 1977), pp. 460-468

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\* Author not at Lincoln Laboratory.

# UNPUBLISHED REPORTS

## Journal Articles

JA No.			
4710	Micro Fresnel Zone Plates for Coded Imaging Applications	N. M. Ceglio* H. I. Smith	Rev. Sci. Instrum. <u>49</u> , 15 (1978)
4746	Spectroscopy and Lasing of a High Nd Concentration Al-Phosphate Glass	A. Lempicki* R. M. Klein* S. R. Chinn	Accepted by IEEE J. Quantum Electron.
4755	Doppler-Limited Spectra of the C-H Stretching Fundamentals of Formaldehyde	A. S. Pine	Accepted by J. Mol. Spectrosc.
4786	Collisionless Intramolecular Energy Transfer in Vibrationally Excited SF <sub>6</sub>	T. F. Deutsch S. R. J. Brueck	Accepted by Chem. Phys. Lett.
4790	Wavelength Dependence of GaAs Directional Couplers and Electrooptic Switches	F. J. Leonberger J. P. Donnelly C. O. Bozler	Accepted by Appl. Opt.
4799	Ultraviolet Photoemission Measurements of the Band Structure of TiO <sub>x</sub> (0.93 ≤ x ≤ 1.15)	V. E. Henrich H. J. Zeiger T. B. Reed	Accepted by Phys. Rev. B
4801	Efficient Phasematched Infrared Third Harmonic Generation in Liquid CO-O <sub>2</sub> -SF <sub>6</sub> Mixtures	S. R. J. Brueck H. Kildal	Accepted by Opt. Lett.
4802	Simplified Fabrication of GaAs Homojunction Solar Cells with Increased Conversion Efficiencies	J. C. C. Fan C. O. Bozler R. L. Chapman	Accepted by Appl. Phys. Lett.
4808	GaInAsP/InP Avalanche Photodiodes	C. E. Hurwitz J. J. Hsieh	Accepted by Appl. Phys. Lett.
4810	Oriented Crystal Growth on Amorphous Substrates Using Artificial Surface Relief Gratings	H. I. Smith D. C. Flanders	Accepted by Appl. Phys. Lett.
MS-4437	Alignment of X-ray Lithography Masks Using a New Interferometric Technique - Experimental Results	S. A. Austin* D. C. Flanders H. I. Smith	Accepted by J. Vac. Sci. Technol.
MS-4438	Polyimide Membrane X-ray Lithography Masks - Fabrication and Distortion Measurements	D. C. Flanders H. I. Smith	Accepted by J. Vac. Sci. Technol.

\* Author not at Lincoln Laboratory.

JA No.

MS-4543	Chemisorbed Phases of O <sub>2</sub> on TiO <sub>2</sub> and SrTiO <sub>3</sub>	V. E. Henrich G. Dresselhaus H. J. Zeiger	Accepted by J. Vac. Sci. Technol.
MS-4544	Surface Photovoltage Experiments on SrTiO <sub>3</sub> Electrodes	J. G. Mavroides D. F. Kolesar	Accepted by J. Vac. Sci. Technol.

Meeting Speeches\*MS No.

4140F	Photoelectrolysis of Water	J. G. Mavroides	Fall Symp., McGill University, Montreal, Canada, 19 November 1977
4358A	Integrated Optics	I. Melngailis	New Technology, M.I.T., 1 February 1978
4392A	Tunable Infrared Lasers	A. Mooradian	Conf. on Lasers and Electro-optical Systems (CLEOS), San Diego, California, 7-9 February 1978
4537A	Vibrational Energy Transfer Processes in Simple Cryogenic Liquids	R. M. Osgood, Jr.	Seminar, Allied Chemical, Morristown, New Jersey, 30 November 1977
4581	The Electronic Structure of Defect Surfaces: Chemisorption on Transition-Metal Oxides	V. E. Henrich	Seminar, University of Maine, Orono, 18 November 1977
4582	Efficient Third Harmonic Generation of CO <sub>2</sub> Laser Radiation in Liquid CO-O <sub>2</sub> -SF <sub>6</sub> Mixtures	H. Kildal S. R. J. Brueck	Topical Mtg. on Inertial Confinement Fusion, San Diego, California, 7-9 February 1978
4588	Acoustically Scanned Optical Imaging Devices	F. J. Leonberger	IEEE Boston Section Group on Sonics and Ultrasonics, Bedford, Massachusetts, 7 December 1977
4592	GaInAsP/InP Avalanche Photodiodes	C. E. Hurwitz J. J. Hsieh	Topical Mtg. on Integrated and Guided Wave Optics, Salt Lake City, 16-18 January 1978
4607	Semiconductor Waveguide Switches	F. J. Leonberger	
4612	High Sensitivity, GHz-Bandwidth HgCdTe Heterodyne Receivers	D. L. Spears	Seminar, Honeywell Electro-Optical Center, Lexington, Massachusetts, 30 November 1977

\*Titles of Meeting Speeches are listed for information only. No copies are available for distribution.



SOLID STATE  
DIVISION 8

I. SOLID STATE DEVICE RESEARCH

A 12-element, 1.4-GHz bandwidth HgCdTe photodiode array designed for rapid target acquisition for a CO<sub>2</sub> laser radar has been developed with measured individual element heterodyne sensitivities better than  $7 \times 10^{-20}$  W/Hz and  $11 \times 10^{-20}$  W/Hz at 760 MHz and 1.5 GHz, respectively. RF crosstalk between elements was found to be less than -22 dB at 1.4 GHz.

The gap-coupled Si-diode array/LiNbO<sub>3</sub> acoustoelectric memory correlator has been operated as a linear optical imager device and at a scan rate compatible with real-time imaging systems. It has been shown that 40 mW/cm<sup>2</sup> can be detected in 15 msec; this corresponds to a sensitivity of 600 pJ/cm<sup>2</sup>.

Life tests on 13 CW, room-temperature GaInAsP/InP double-heterostructure diode lasers are being carried out. Lifetimes have ranged from a few hundred to 7500 hours, with three devices still operating. For most of the lasers which have failed, end-face degradation has been identified as the primary cause of failure.

Pulse response and modulation experiments have been carried out on GaInAsP/InP diode lasers and yield output pulse risetimes of approximately 250 psec and a modulation of 200 Mpps. When the DC bias was just below the laser threshold, the damped relaxation oscillation is minimized and a relatively clean output pulse is obtained.

An automatic system which measures the Hall coefficient and electrical resistivity versus temperature from 4 to 300 K has been constructed and operated. The apparatus is being used to characterize LPE growth of InP and InGaAsP alloys. Analysis of the data shows the donor and acceptor impurity concentrations in a LPE grown film of InP to be  $1.8 \times 10^{16}$  cm<sup>-3</sup> and  $6.5 \times 10^{15}$  cm<sup>-3</sup>, respectively.

II. QUANTUM ELECTRONICS

Using a dynamic electrical heating technique, the thermal conductivity and specific heat have been determined for NdP<sub>5</sub>O<sub>14</sub>, a high-Nd-concentration laser material. The measured values of the thermal conductivity tensor elements (in W/cm-K) are  $\Lambda_a = 2.10 \times 10^{-2}$ ,  $\Lambda_b = 9.66 \times 10^{-3}$ , and  $\Lambda_c = 1.40 \times 10^{-2}$ . The specific heat is 0.141 cal/g-K, in excellent agreement with the value of 0.139 cal/g-K that was measured by differential scanning calorimetry.

A study of the spectral output characteristics of a Ni:MgF<sub>2</sub> laser operating at a wavelength of 1.64  $\mu$ m has indicated that the transition is primarily homogeneously broadened. The fluorescence lineshape and lifetime have also been measured in Ni:MgF<sub>2</sub> as a function of temperature, polarization, and Ni concentration. In addition, the lineshape and lifetime as a function of temperature have been observed for Co:MgF<sub>2</sub> and Ni:MgO.

Measurements have been made of the CO<sub>2</sub> laser induced breakdown parameters of the cryogenic liquids CO, O<sub>2</sub>, N<sub>2</sub>, and Ar for various spot sizes and pulse durations. The underlying physical mechanisms have been considered.

Ultraviolet association of diatomic molecules has been examined as a mechanism for inverting a tunable gas laser and as a means of investigating the structure of molecular species which are unbound in their ground state. Spectroscopic studies have been carried out on Hg<sub>2</sub><sup>\*</sup> and XeBr<sup>\*</sup>.



A technique for optically extracting the energy stored in metastable  $\text{Hg}_2^*$  has been considered. The process uses an infrared laser, such as HF, to transfer the relatively large population in the  $\text{O}_g^\pm$  levels to the  $1_u$  radiating level. As a result, inversion on the  $1_u \rightarrow \text{O}_g^+$  (300 nm) transition can be created. Measurements have been made of HF laser induced UV emission.

Ultraviolet photolysis of  $\text{HgBr}_2$  has been used to generate a pulsed green laser at 502 nm. The laser, which operates on the  $B \rightarrow X$  transition of  $\text{HgBr}$ , was longitudinally pumped with a 4-mJ ArF laser.

Radiometric sensitivity measurements have been made on a quasi-optical receiver in the spectral range 170  $\mu\text{m}$  to 1 mm. Using GaAs Schottky mixer diodes in a corner-reflector configuration, total system noise temperatures of 9680 K (DSB) have been obtained at 447  $\mu\text{m}$ .

### III. MATERIALS RESEARCH

In an investigation of the feasibility of fabricating infrared photocathodes utilizing a graded-gap  $\text{Hg}_x\text{Cd}_{1-x}\text{Te}$  structure, it has been found that the rapid diffusion of Cs into CdTe precludes the use of emitting surfaces prepared by direct cesiation of CdTe. To determine whether bias-assisted, transferred-electron photoemitters can be made by the cesiation of a thin metal overlayer that forms a Schottky barrier on p-CdTe, the diffusion of Cs into a number of potentially useful metals has been investigated. For Al, Ti, and Cr, which were found to have low Cs diffusion rates, the work functions of cesiated surfaces have been determined and initial measurements have been made on the properties of Schottky barriers formed by these metals on p-CdTe.

In order to provide a single-crystal sample of  $\text{CdGeP}_2$  large enough for measurement of the electrooptic coefficients, a technique has been developed for the synthesis and crystal growth of this II-IV- $\text{V}_2$  chalcopyrite. A single crystal whose size (volume  $\sim 5 \text{ cm}^3$ ) and optical transmission considerably exceed the minimum requirements for the electrooptic measurements has been obtained from an ingot prepared by this technique, which uses the horizontal gradient-freeze method for directional solidification of a near-stoichiometric melt formed by reaction of the three elements in a sealed fused-silica ampoule.

### IV. MICROELECTRONICS

Oriented crystal growth on an amorphous substrate has been achieved using an artificially created surface-relief grating. Crystallites of KCl grown from a water solution onto a 320-nm spatial-period square-wave grating in  $\text{SiO}_2$  nucleated preferentially at vertical steps and grew with  $\langle 100 \rangle$  directions parallel to the grating axis. It is proposed that artificially created surface microstructures may provide a new means of manipulating the growth and orientation of crystal-line overlayers.

Reactive ion etching with  $\text{CHF}_3$  gas has been combined with plasma etching in  $\text{CH}_4 + 5\% \text{ O}_2$  to produce submicrometer geometry patterns in glass films on GaAs substrates. Reactive ion etching is used to etch the glass to within approximately 1000 Å of the glass/GaAs interface, and plasma etching then removes the remaining glass without damaging the GaAs substrate. Steep-edged walls and precise dimensional control have been achieved for both  $\text{SiO}_2$  on GaAs and phosphosilicate glass/ $\text{Si}_3\text{N}_4$  on GaAs with this technique.

### V. SURFACE-WAVE TECHNOLOGY

Surface-acoustic-wave properties of fresnoite have been calculated from bulk material parameters and have been measured along several orientations on samples cut from Czochralski-grown crystals. Favorable properties are measured for the z-cut, x-propagating wave: the

coupling coefficient,  $k^2$ , is  $0.016 \pm 0.003$ , the velocity is 2678 m/sec, and the temperature coefficient of delay is  $51 \times 10^{-6}/^\circ\text{C}$ . These values, as well as those measured for the much lower coupling x-z and x-y surface waves, are in agreement with calculations. The calculations also predict that for surface waves propagating in the x direction on a surface whose normal is at  $45^\circ$  to z and y axes, the coupling coefficient is 10 percent higher than calculated for the above z-x case.

The mode structure of acoustic waves propagating in gap-coupled acoustoelectric convolvers has been theoretically analyzed. When a silicon strip is supported above a  $\text{LiNbO}_3$  surface by a structure consisting of parallel rails, these rails strongly influence the surface-wave propagation. Rail support structures have been modeled as a periodically loaded transmission line. The loading caused by rails has been calculated as a function of rail width and spacing. Mode profiles and beat lengths between modes have been predicted and they agree well with experimental measurements.

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